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Business and Life in Space

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The suggested title — "Business and Life in Space" — seems a little bit tame for my tastes. I would rather entitle my talk, "The Ecstasy and the Agony". The reason for this will become apparent from my remarks.

First the ecstasy — including the joys of space-flight and the ingenious environmental systems we humans have invented to enable such flights. I am going to use some analogies between space travel and the Columbus voyages. There are some interesting similarities — and some very obvious differences — between the voyages of Columbus and the Space Shuttle *Columbia*. One difference is that our spaceships always start out traveling east, not west. The initial speed of a spaceship is probably even slower than the speed of the Columbus ship — about a mile an hour as it moves very slowly towards its launch pad. Some time later though, the analogy breaks down dramatically. For example, a spaceship is not westward bound, but upward bound into and across unknown oceans (Figure 1). The oceans of space are better known now than they were 30 years ago when the space age began, but there is still much to be learned.

I am going to talk some about the life support systems in this machine we call the Space Shuttle and then later about life support systems in a little cocoon that is far smaller than the shuttle. I like to think of it as a cocoon. The more common term is a space suit. A lot of numbers and design aspects of these machines are rather intriguing. For example, the space ship would tend to heat up during the outbound journey, so we evaporate overboard both ammonia and water during the ascent to orbit

in order to keep the crew compartment at a comfortable room temperature.

Another Columbus comparison that intrigues me is related to the story that Columbus's crew was very fearful of sailing to the edge of the Earth and falling off. Now, I think it must be the case that Columbus himself knew that was not going to happen, and Queen Isabella knew that was not going to happen. The intelligentsia of those times knew the world was round, the only argument was how big was it. Columbus felt it was rather small and he loaded his ships with enough food and water to carry him around the small Earth to India. As it turned out this world is not as small as Columbus estimated and he did not get to India. Luckily though he did not have to rely, as a life or death matter, on his closed environmental systems either. He was able to resupply food and water from a "new" continent that we now know as America. Queen Isabella didn't care whether Columbus lived or died anyway. Odds were that she was going to lose her money, but she had bet on his somehow surviving because, if he did, it solved one of her major political problems. As they say, the rest is history. Governments were clearly a little more cavalier about their explorers in those days than we are in this considerably more timid age.

To repeat, we are told that the Columbus crews of the *Nina*, *Pinta* and *Santa Maria* were afraid of falling off the Earth. We, the *Columbia* crew of the *Discovery*, sailed for eight minutes and our modern technology enabled us, on purpose, literally to fall off the edge of the Earth. This is an absolutely correct statement in physics. When the engines

shut down, we are falling and we continue to fall, fall, fall around in orbit. We remain in this perpetual free fall until it is time to come home. I will give you some more intuitive ways to think of free fall in just a moment.

Life aboard a spaceship: we are basically in a rather small cabin. Physically, were we to be in such a small room or mid-deck volume here on the ground, you would find it very crowded indeed, particularly if there are as many as eight people inside. In space, a small volume is not nearly so confining — the reason being of course that people float all over the place. In fact, you can sleep on the walls, you can hover on the ceiling, you can disappear into little nooks and crannies in any direction. Even a small volume becomes rather spacious in space because you are living in all three dimensions. On Earth we humans are confined largely to the area of the floor. This is no doubt why the size of a home or apartment is cited in area (square footage) rather than in volume.

Let me talk about aspects of space food. We eat largely freeze-dried reconstituted TV-like dinners. This, by the way, is an example of the "stow and throw" philosophy that we heard about yesterday. There is nothing "closed-system" about this. When we finish consuming a pre-packed meal, we throw the packaging and the remnant food away. One of the constraining aspects of the "consumables" in the Space Shuttle is that we run out of trash stowage volume fairly quickly. Although we run out of liquid oxygen and liquid hydrogen that give us the necessary electrical energy in a Space Shuttle in a little over a week, we would have to come home in about two weeks anyway because we would literally run out of places to stow the trash. We do not throw trash overboard. The Russians do throw it overboard, however.

Although the orbiter looks like an airplane, it is not like an airplane at all and living aboard an orbiter in space is very much like living aboard a ship. There is no engine sound. By no sound, I mean no constant engine noise, thus the cabin sounds like a modern computer-filled office. The pressure of the crew compartment is kept at one atmosphere, i.e., 14.7 p.s.i. When you go into space, your ears don't even pop. The humidity is

also very carefully controlled. Given the fact that we are all from Houston, it is controlled at 100% — well, perhaps at 50%. Life in space is somewhat like being aboard a submarine but with one remarkable difference. There are 10 windows in an orbiter and in many ways, they make all the difference. Even though they are somewhat recessed and thus not easy to look through, very shortly after you arrive in orbit each window is covered with "nose smudges".

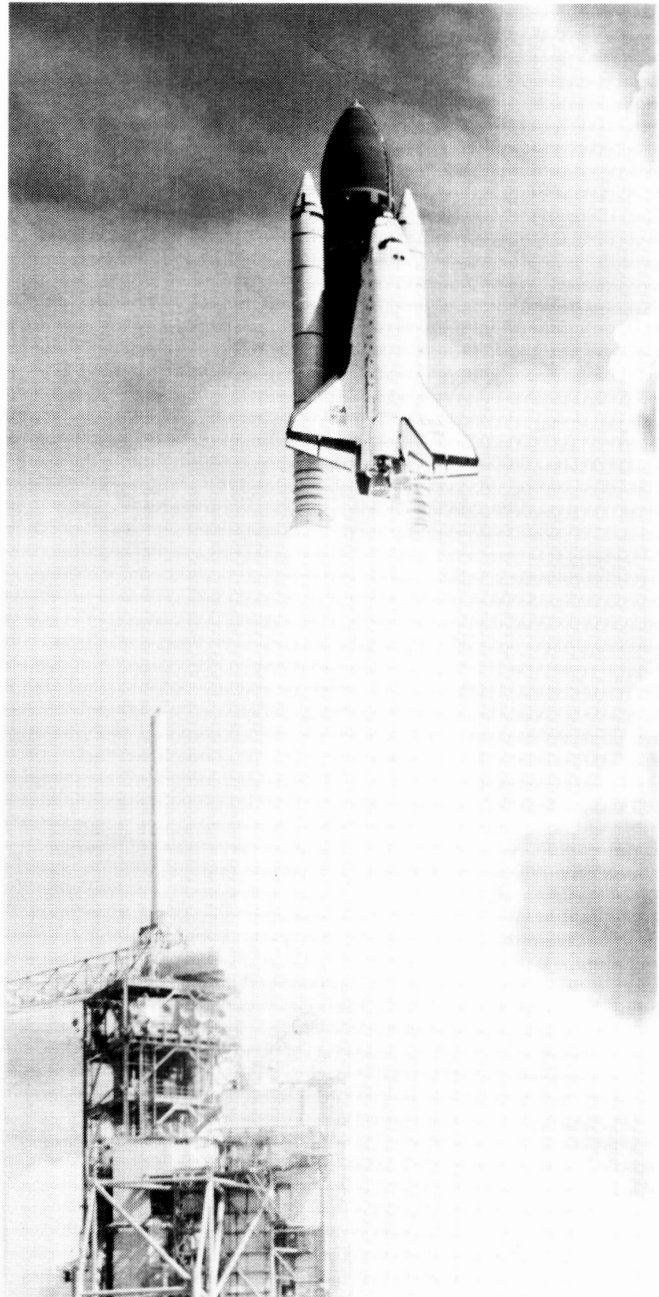


Figure 1. The Space Shuttle Columbia on launch from Kennedy Space Center, Florida.

Looking at Earth photos taken through these "windows on the world" the atmosphere appears as thin as an onion skin. It is not hard to believe that one could punch an ozone hole in something only that thin. You of course don't see ozone damage, but you do see the delicateness of the atmosphere with your eyes all of the time. In this photo (Figure 2) we see in one frame the Pinacate Mountains, the area of Biosphere 2, and further up the

California coast we can see where Ames Research Center has moved 16 inches closer to San Francisco during the recent earthquake. That is pretty much the scope of what your eyes see from orbit. But the photos you see are only still photos — the scene from orbit is always moving. In orbit we would be traveling at about 5 miles a second, so during the time that we have looked at this photo we would be speeding past the Gulf of Mexico,

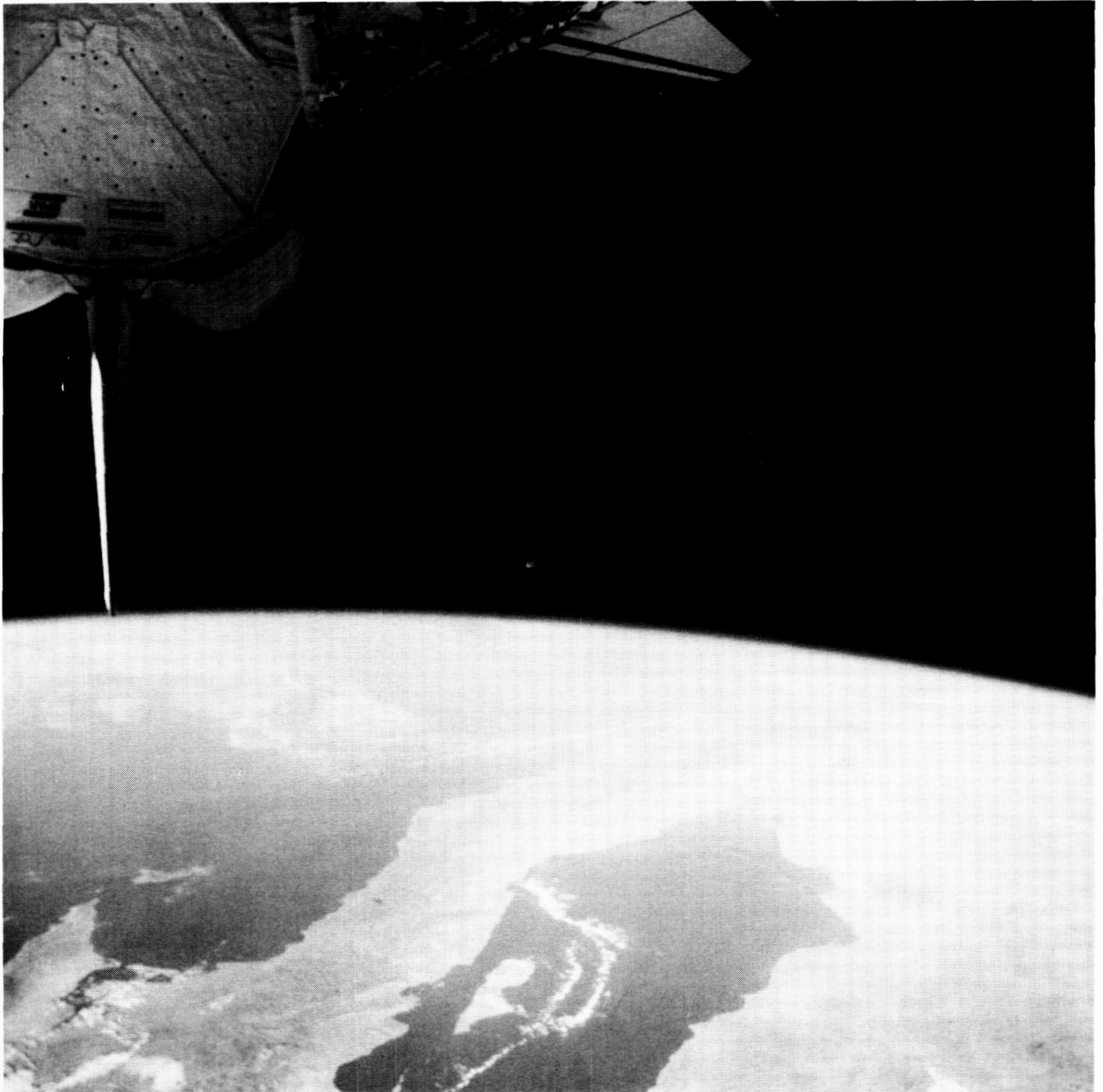


Figure 2. Baja California and the west coast of the United States as seen from the Space Shuttle. (NASA)

were we in space right now. I will confess that it is very difficult to do the Government's work when the Government gives you all of these windows to look out of.

Back to more technical things. The orbiter is literally an envelope of Earth with windows. The consumables within the envelope that we run out of first is electrical power generated by hydrogen and oxygen combined in fuel cells. The next thing

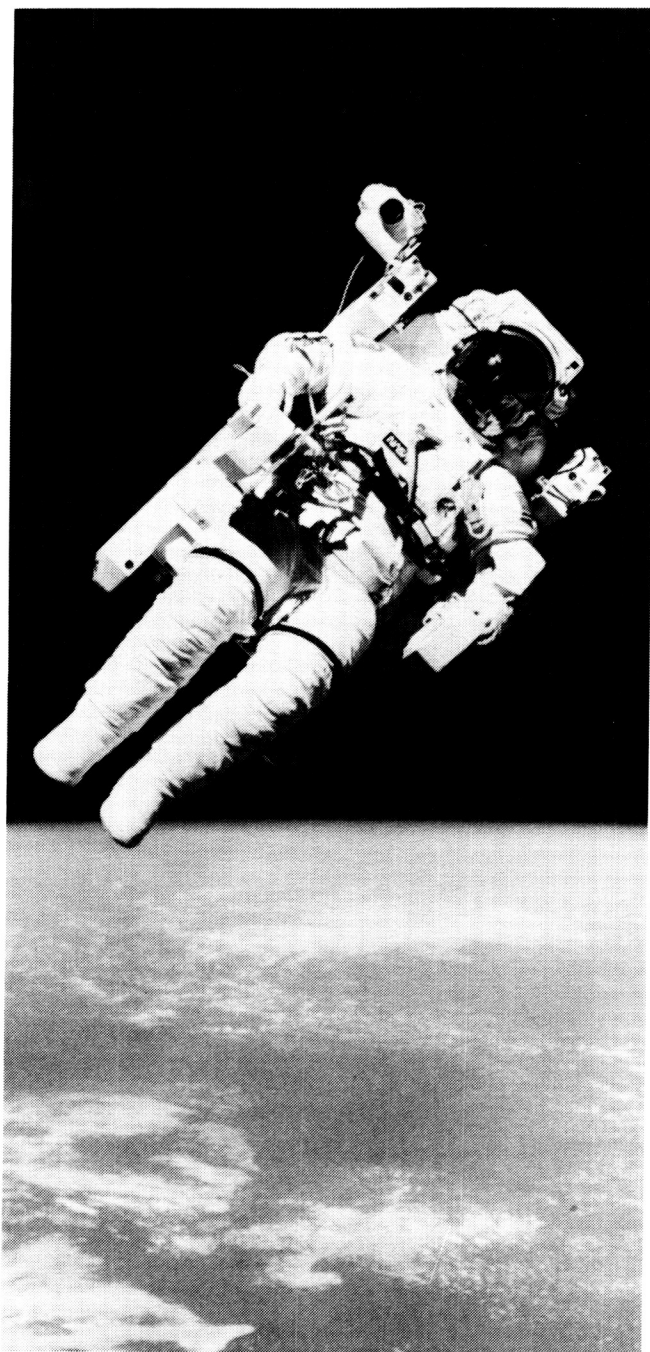


Figure 3. Astronaut in EVA space suit. (NASA)

we would run out of is volume for storing waste. Then we would run out of food. We would also run out of lithium hydroxide containers that are scrubbing the CO_2 out of the atmosphere and ultimately we would exhaust the oxygen supply from which we are breathing but oxygen is used for other things as well. For example, oxygen is combined with hydrogen in fuel cells to generate electricity. A by-product is water that we drink. The O_2 and H_2 when combined in fuel cells also generate heat and the heat is dumped (dispelled) through radiators. On balance we wind up with too much water and we actually must dump water overboard from time to time. When we dump water there is always a fight to get to the window nearest the dump port because the sight is like orbiting the Earth inside a blizzard. The water comes out, immediately freezes and sublimates away, but you are enveloped in a snow storm for just a moment when that happens.

This is the cocoon I spoke of earlier (Figure 3), a person in a space suit. This person is kept warm, supplied with oxygen at 3 p.s.i., given pressure, which is also important so that she can fill her lungs and absorb the O_2 into the blood stream, and supplied with a radio so that she can talk to friends and neighbors. One is typically asked, "aren't you lonesome out there in your spacesuit?" The answer is "no", because somebody is always talking to you. In addition, you feel all bundled up, exactly like when your mom put you in your snowsuit many years ago. You do feel very encumbered and, although it is a comforting feeling, it can be a frustrating feeling at the same time. For example, the minute you put on your helmet you can no longer scratch your nose, or any other part of your anatomy, I might say. If you have a tear in your eye, you can not rub your eye nor does the tear roll out of your eye. It stays and you will spend some minutes looking through the tear drop as though you are under water. Interestingly this tiny bit of our human environment would tend to heat up in the space environment without active temperature control. It is kept cool by evaporating water from a metal plate located in the back pack. The first thing that this suit will run out of is cooling water. We watch very closely the cooling water level and the

minute it gets down to the last bit of water the next procedure is to return to the orbiter. The spacesuit is outfitted with food inside, candy bars that fit down in front of the suit and that you can get to with your mouth. The technique is pull up the candy bar and then bite it off. Don't bite it off and then raise your head. Note that it is very important to remember the correct sequence. It takes astronauts a long time to learn but once you get hungry enough, you have learned; otherwise, you might stay in the suit for a full eight hours with no nourishment. There is also fluid stored inside the space suit and a straw that you can get to with your mouth — the drink could in theory be the liquid of your choice, but the Government does limit the selection to water or Gatorade. They totally ignored my request. As far as other body functions are concerned, once again you must use the only technique available to you when bundled up by your mother in the snowsuit. If you have to go, you just hope the diaper doesn't leak.

There are three satellites in Figure 4 — part of the orbiter, which is a satellite, the communication

satellite named *Westar* and a "satellite" named *Dale Gardner*.

Figure 5 is in a sense a demonstration of the zero-gravity which results from the falling around planet Earth. The object shown is not a child's balloon, rather it is a photograph of floating liquid taken inside the spaceship. It is a cola soda. It's a well-known substance, but you have never seen it in this state. When you drink a carbonated soft drink in zero-gravity you notice the bubbles don't know which way "up" is. In other words, the carbon dioxide bubbles don't rise to the surface and pop out because without gravity there is no buoyancy to move the light gas to the surface of a heavy liquid. Once again, there is no up or down here. To dispatch the liberated fluid, you can drink it with a straw or you can just attack it with a wide open mouth.

During the reentry of the orbiter into the Earth's atmosphere — although in this photo it is nighttime outside — we see light from the ion glow caused by hitting the air molecules at around MACH 20 [20 times the speed of sound]. The orbiter comes home



Figure 4. Astronaut Gale Gardner in an EVA from the Space Shuttle with a communications satellite. (NASA)

making enormous "S turns", which is a subject of another lecture. Figure 6 is a photo that I rarely show of the view looking out the back of the ship. The tail would be here, if we could see it. It is the image of the ion glow spilling around behind the orbiter. The glow waxes and wanes, moves and flickers in size, color and intensity. I wanted to show this slide yesterday, Halloween, because it looks for all the world like the most eerie figure. When you first see it, you hope it is the Angel of Good Technology, not the Angel of Bad Engineering. My final photo (Figure 7) taken at the end of the first flight of Space Shuttle *Columbia*, comes with a newspaper headline, "Today a spaceship landed on planet Earth."

I want to go from the ecstasy to the agony of space exploration. The ecstasy, of course, comes from our past space accomplishments; the agony comes from the bureaucratic snarl that is increasingly smothering our potential for future accomplishment. In short, although through our technology we are now in a position to undertake truly astonishing projects, the way our nation's laws are being applied make these undertakings nearly impossible. Indeed, I contend that the greatest

challenge to us space workers is not unraveling and applying the laws of nature to space exploration, but rather, finessing around the ponderous laws that have been put in place by the military, industrial, and bureaucratic political complex. Those are very long words — I don't mean to appear pessimistic about it — but I frankly am very worried about our ability to move forward as a nation and undertake, successfully, many of the projects that we have the technology, the energy and the conviction to do.

I am going to give two examples that are indications of this unfortunate trend. The first example is the current Space Station, and the second is an example that I have imagined just for this occasion. If we look into the night sky we can find the lights of an orbiting Space Station — the *Mir* of the Soviet Union. I would have loved to have brought a picture of the American Space Station. Unfortunately, it's in the form of boxes and boxes of plans that would fill this room many times over. We have no actual Space Station, but the other Space Station is working right now. People are in the Space Station. They are called "cosmonauts." We at Space Industries have an experiment going aboard this Rus-

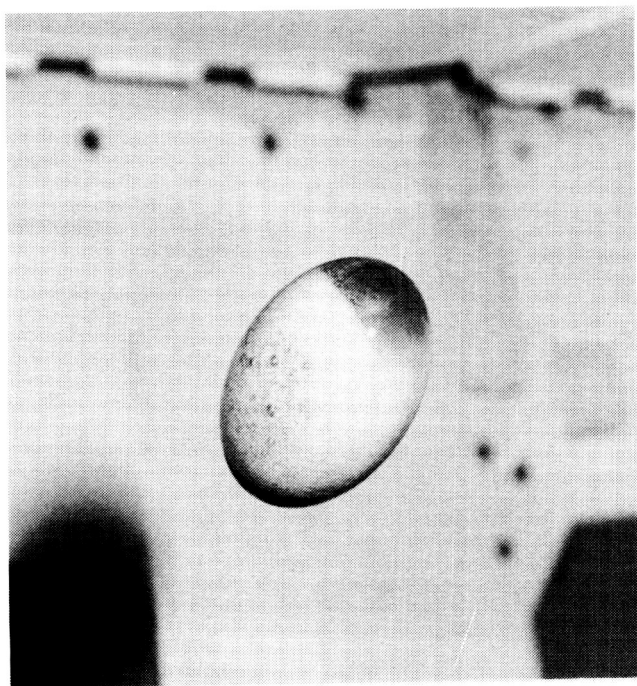


Figure 5. Cola soda in the microgravity environment of the Space Shuttle. (NASA)

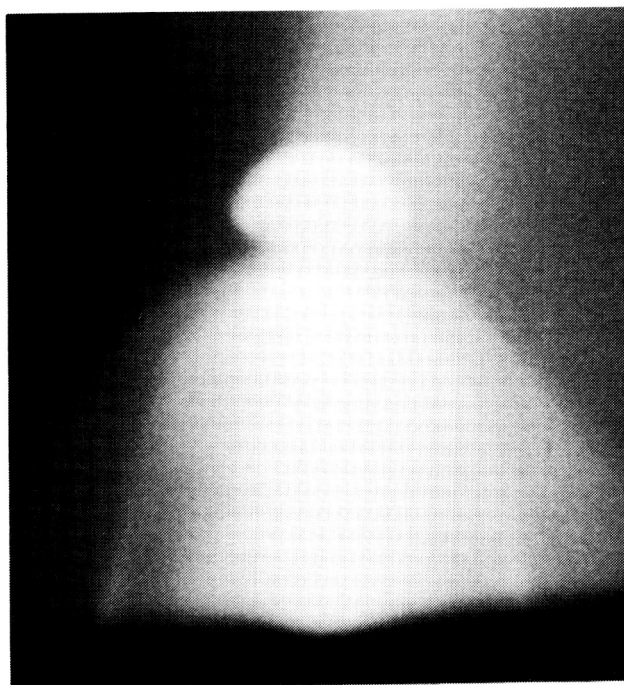


Figure 6. The ion glow spilling around behind the Space Shuttle orbiter. (NASA)

sian station in six weeks. It was the only place we could take it. The Russians have made it very convenient for us to fly with them and we are going to do it.

However, in this country we have a commitment to a Space Station and, indeed, to implement such a project should be nowhere near as difficult as an Apollo project. It is, in fact, not as difficult as the Biosphere 2 because we already have built a practice Space Station. We called it Skylab. It was done with monies left over from Apollo — about a billion dollars. We talked about Skylab in '68 and '69, we constructed it in the early '70s and we flew it in 1973. So a Space Station is not something new. The official International Space Station was committed to by President Reagan in 1984. It was to be flying in 1992 in time for and in celebration of the 500th anniversary of the discovery of America. Thus, when we committed to it, the Space Station was eight years ahead of us. Well, some years

have passed. We are now in 1989, nearly 1990. Where is the Space Station? The best estimate is that it will be ready in 1999 — now 10 years ahead of us. Thus between 1984 and 1989, we have spent over \$2 billion on the Space Station and we have lost two years. Because of bureaucratic inefficiencies the faster we go, the behinder we get.

I will add another thought. There are some numbers around which reflect the costs of the early space machines, both what they cost and how the resources were put into them. For example, when you look at the Apollo spaceships, you will see that about forty percent of the cost of Apollo went in either to the hardware or to the wages of the people who were building the hardware. If you look currently at the monies that flow into the Space Station you will see two billion dollars are going into this Space Station just this year [1989]. Two billion. By the end of this year you would think that we would have a piece of metal some place to show for the

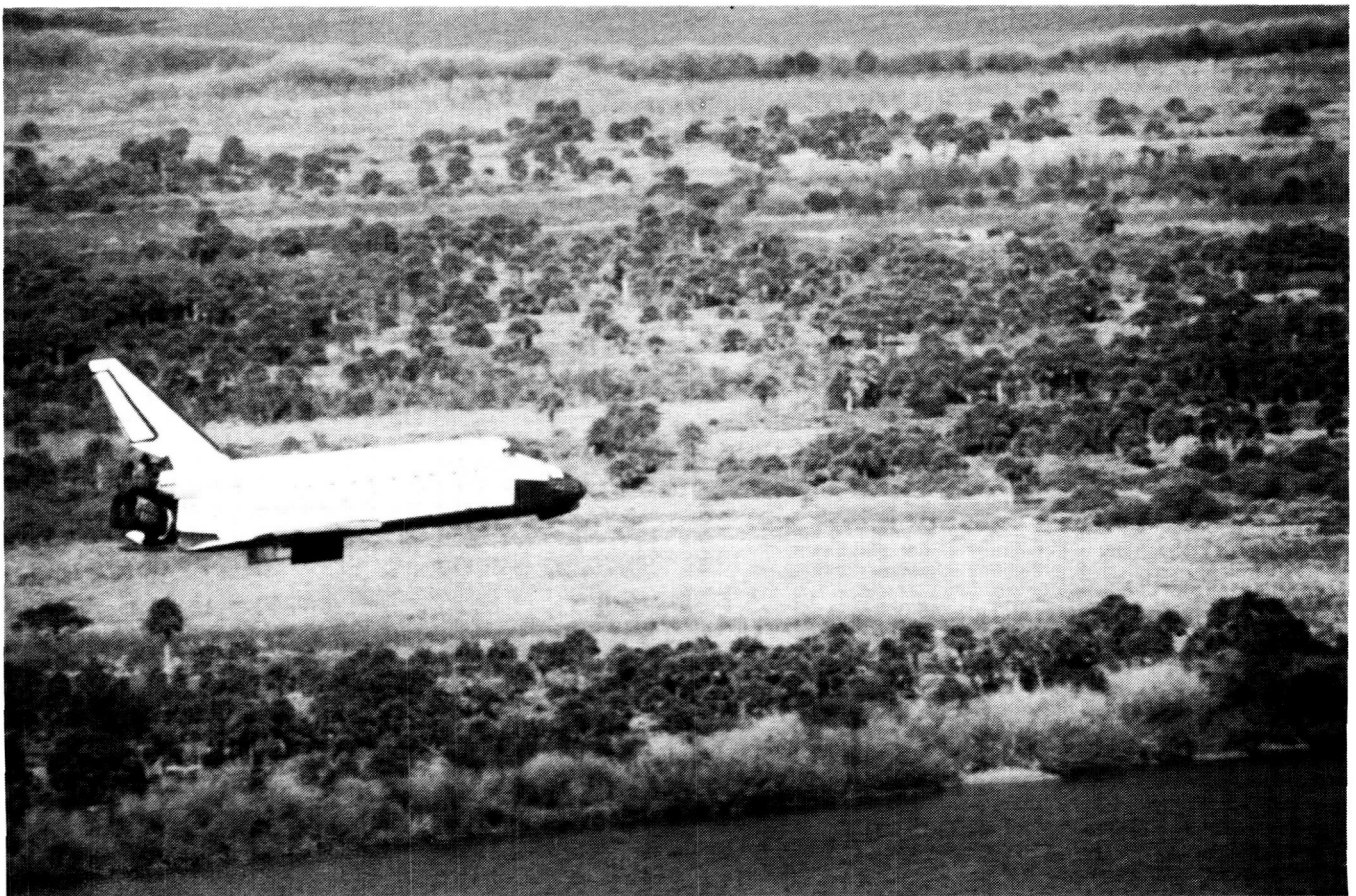


Figure 7. Space Shuttle *Columbia* preparing for landing after its first spaceflight. (NASA)

money. We won't. Maybe \$500 million will go towards actual hardware, however, of the \$500 million, the Congress actually cut \$250 million and so that cut comes out of the actual production of the machine. And the remaining 75% of the \$2 billion, purely overhead, continues to consume all the rest of that money. The trend is that pretty soon we will be spending infinite money and getting zero product to show for it.

Let me end these thoughts by projecting a scenario which I fear could actually happen. First of all, I join all of my associates from NASA in congratulating and encouraging those of you who are associated with Biosphere 2. This Biosphere 2 project literally feels like NASA felt to us NASA-ites in the old days. Keep after it. It is a wonderful feeling. It doesn't mean you are going to do everything right, but you are at least doing things. Let's assume that there are elements of what you do that, in fact, actually work. We also know that on the 20th anniversary of the Moon Landing our President announced that, in addition to the Space Station, we are going to return to the Moon, this time to stay, and then travel further on to Mars. Wonderful words. I would assume that in response to this challenge our government officials will need information about biospheres.

Let us examine how our government will procure information about biospheres. Government officials will need to lay out a set of requirements. Many workshops, studies and hundreds if not thousands of consultants will be involved. It will take at least a year to lay out requirements for information on biospheres needed in order to undertake a lunar colony. From those requirements, still more committees will derive a set of specifications that contractors will have to meet through contractor developed designs of possible biosphere configurations. These specifications will be formally detailed in a "Request for Proposal for Phase B". The U.S. aerospace industry will respond to this formal request with equally formal proposals — each proposal from a team composed of various large companies and each describing what that team could do in terms of meeting the specifications which in turn will satisfy the requirements.

Let's assume that Space Biosphere Ventures

would like to participate in this Government competition. You would have to spend at least \$200,000 just to submit your proposals in competition for the Phase B study money. This effort would take a half a year of your time. It pains me to predict that your team would also be found "incapable" of studying a biosphere because of many things that the government requires in order for a particular group to be a legitimate government contractor. In any case, the government considerations on who is the proper vendor for a Biosphere G (the Government Biosphere) would unfold for months and months. Years would pass and ultimately a phase C and D contract — to build Biosphere G — would be given to the winners of the contract. They would be Lockheed, Boeing or McDonnell Douglas — well-known aerospace companies, but extraordinarily expensive. I am certain that by the time of those awards more tax money would have been spent on studying Biosphere G than you are going to spend here on doing Biosphere 2. And years will have passed. By the time Biosphere G is officially undertaken I hope to goodness that you will be well along on your Biosphere 8 and, furthermore, that Biosphere 8 will be either outbound or already located somewhere in the far reaches of our amazing Solar System.

It is very distressing and I realize I don't sound optimistic. But in the long run I am very optimistic, partly because of places like Space Biosphere Ventures. If our government is unable to make progress, that does not mean humanity is going to be unable to do it.